

1 **Fibrous Cartilage Formation in the Acetabular Fossa after Periacetabular**

2 **Osteotomy: Evaluation of the Related Factors and Clinical Outcomes**

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9

1 **Abstract**

2 *Background:*

3 We performed second-look arthroscopy at approximately 1 year after periacetabular
4 osteotomy (PAO) to evaluate fibrous cartilage formation in the acetabular fossa, and to
5 explore the related factors such as the hip morphological features associated with such
6 fibrous cartilage formation.

7 *Methods:*

8 We performed PAO combined with hip arthroscopy in 64 patients (63 women, 1 man;
9 mean age, 38.3 years at the time of primary operation) who underwent second-look
10 arthroscopy and were included in this study. Patients with a Perthes disease were excluded.
11 Patients were divided into two groups based on the presence or absence of fibrous
12 cartilage formation (formation group, 37 hips; non-formation group, 27 hips). The
13 formation group and non-formation group were compared for age, body mass index
14 (BMI), period between primary operation and second-look arthroscopy, Harris hip score
15 (HHS), and radiographic parameters, including the lateral center-edge (CE) angle,
16 acetabular roof obliquity (ARO), vertical-center-anterior (VCA) angle, and depth of the
17 acetabular fossa (DAF).

18 *Results:*

We found that patients in the formation group had superior postoperative HHS to patients in the non-formation group ($P < 0.05$). DAF was significantly higher in the non-formation group than in the formation group ($P < 0.05$). There was no significant difference between the two groups in terms of age ($P = 0.40$), BMI ($P = 0.45$), lateral CE angle ($P = 0.62$), ARO ($P = 0.35$), or VCA angle ($P = 0.26$) at the time of primary PAO as well as at the time of second-look arthroscopy.

Conclusion:

Patients who showed fibrous cartilage formation in the acetabular fossa had a better HHS than those without fibrous cartilage formation.

Key words: Second-look arthroscopy, Periacetabular osteotomy, Developmental dysplasia of the hip, Acetabular fossa, Fibrous cartilage formation

Footnotes

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Introduction

Periacetabular osteotomy (PAO) is one of surgical treatment options for patients with symptomatic acetabular dysplasia¹⁻⁵. The survival rate for these patients at the 10-year follow-up is reported to be about 84% to 90% with arthroplasty as the endpoint^{6,7}. PAO reportedly reduces the stress on the hip caused by a significant increase in the weight-bearing surface of the hip joint⁸⁻¹⁰. A previous study of a rabbit model indicated that chondrocytes have been activated in the early postoperative stage in response to load stress¹¹. Similarly, in humans, adjusting this weight-bearing surface tends to result in fibrous cartilage formation in the acetabular fossa and they reported the fibrous cartilage formation is good sign to express the remodeling of the hip joint¹⁰. However, few reports have investigated the acetabular fossa by hip arthroscopy at 1 year after PAO⁹, and the incidence and potential pathological consequences of this fibrous cartilage formation have never been examined. The present study aimed to evaluate fibrous cartilage formation in the acetabular fossa after PAO, and to explore the potential factors for such fibrous cartilage formation.

Patients and Methods

This retrospective study was approved by our institutional review board (approval number: 16-1-08).

From September 2011 to September 2015, PAOs were performed at our institution in patients who presented with symptomatic acetabular dysplasia of the hips. We performed PAO combined with hip arthroscopy in 114 patients. Two patients with a Perthes disease were excluded. Sixty-four (56%) of 112 patients underwent second-look arthroscopy at a mean of 15 months (range, 11 to 27 months) after primary operation; these patients were

1 included in this study. No patient had any other orthopedic disorders, such as skeletal
2 dysplasia or neuromuscular disease.

3 Cartilaginous damage was assessed according to the modified Outerbridge
4 classification system: grade 1, normal cartilage; grade 2, superficial fibrillation, softening,
5 or both; grade 3, fragmentation and deep fissuring; and grade 4, erosion down to the
6 subchondral bone¹²).

7 Nine of 64 patients underwent osteochondroplasty at the same time as PAO.
8 Labral tears were not treated at the time of primary operation.

9 10 *Data Collection*

11 Preoperative, intraoperative, and postoperative findings were recorded. We also examined
12 the clinical features, radiological and arthroscopic findings. Age, body mass index (BMI),
13 the period between primary operation and second-look arthroscopy (days), and Harris hip
14 score (HHS) which is an indicator of clinical outcome, were assessed. Radiographic
15 parameters, including the lateral center-edge (CE) angle, acetabular roof obliquity (ARO),
16 and vertical-center-anterior (VCA) angle, were evaluated on anteroposterior pelvic
17 radiographs. All pelvic computed tomography (CT) scans were performed 1 month before
18 PAO. We used a 64-channel multidetector CT system (Aquilion TSX-101A/HA; Toshiba
19 Medical Systems Co.), and the scan protocol had a slice distance of 0.5 mm from the
20 anterior superior iliac spines to below the knee. All images were digitally acquired using
21 the picture archiving and communication system.

22 On CT scans, the depth of the acetabular fossa (DAF) was measured using the
23 supine functional pelvic plane as a reference. First, we confirmed the acetabular roof
24 loaded part (sourcil) along the coronal plane. Second, we confirmed the CT slice of the

1 inner margin of the sourcil along the axial plane. Third, we measured DAF using
2 perpendicular lines from the line linking the front and back of the acetabular fossa to the
3 deepest part of the acetabular fossa (Figure 1a, b).

4 We observed the acetabular fossa during second-look arthroscopy and performed
5 palpation with a probe at second-look. Fibrous cartilage formation was assessed as
6 present when (1) the tissue was a different color from that of the original acetabular
7 cartilage; (2) the tissue had formed more than 2 mm from the acetabular fossa; and (3)
8 the tissue was softer than the acetabular cartilage by palpation with a probe.

9 All operations were performed by the same operator (K.K.). Measurements of
10 all radiographic parameters, and histogenetic evaluations of the acetabular fossa were
11 performed by two investigators (S.I. and S.A.).

12 At the time of second-look arthroscopy, fibrous cartilage formation was observed
13 in the acetabular fossa in patients in the formation group, whereas it was absent in patients
14 in the acetabular fossa (non-formation group). This study was performed by dividing the
15 patients into these two groups to evaluate the difference in the hip morphologic features.

17 *Histopathology*

18 Hematoxylin and eosin-stained image of tissue was obtained from the acetabular fossa
19 during second-look arthroscopy. We collected the chondroid tissues from the first
20 patient and the second patient among the patients of the formation group, and submitted
21 to pathology.

23 *Statistical Analysis*

24 The unpaired *t*-test was used to compare two groups, with the significance level set at *P*

1 < 0.05. Statistical analyses were performed using SPSS version 20.0 software (IBM
2 Corp.).

3 4 *Source of Funding*

5 No external funding was received for this study.

6 7 **Results**

8 The 64 patients comprised 63 women and 1 man, with a mean age of 38.3 years
9 (range, 16 to 64 years) at the time of primary operation. The mean BMI at the time of
10 primary operation was $22.1 \pm 3.8 \text{ kg/m}^2$ (range, 15.6 to 34.1 kg/m^2).

11 The interobserver intraclass correlation coefficient (ICC) were 0.948–0.962 for
12 radiographic parameters. The intraobserver ICC were 0.942–0.957 for CT parameter. The
13 coefficients for intra- and inter-observer correlations indicated good reliability.

14 At the time of the primary operation, cartilaginous damage was found on the
15 acetabular side in 36 hips (grade 1, 18 hips; grade 2, 10 hips; grade 3, 8 hips; grade 4, 0
16 hips) and on the femoral side in 18 hips (grade 1, 13 hips; grade 2, 6 hips; grade 3, 4 hips;
17 grade 4, 0 hips). Some patients showed the formation of chondroid tissue in the acetabular
18 fossa. The histopathological examination revealed this to be fibrous cartilage (Figure 2).

19 At the time of second-look arthroscopy, fibrous cartilage formation was observed
20 in 37 hips (formation group) (Figure 3a, b) and absent in 27 hips (non-formation group)
21 (Figure 4a, b).

22 We found that patients in the formation group had a superior postoperative HHS
23 to those in the non-formation group ($P < 0.05$). The pain score for HHS was significantly
24 better in the formation group than in the non-formation group ($P < 0.05$). DAF was

significantly higher in non-formation group than in the formation group ($P < 0.05$). There was no significant difference between the two groups in terms of age ($P = 0.40$), BMI ($P = 0.45$), lateral CE angle ($P = 0.62$), ARO ($P = 0.35$), or VCA angle ($P = 0.26$) during PAO and at the time of second-look arthroscopy (Table 1).

Discussion

Joint remodeling is a biological reaction caused by a change in the balance of the joint mechanics in response to changes in intraarticular load stress^{7,10,13}. Treating symptomatic acetabular dysplasia with PAO changes the distribution of the load stress on the acetabulum and medializes the femoral head. In turn, however, these biomechanical and anatomical changes can cause an increase in stress to the medial side of the acetabular roof^{14,15}. Indeed, previous studies have found that enlargement of the weight-bearing area is beneficial to the long-term outcome of this procedure^{10,14}.

In light of the findings of others, we hypothesized that redistribution of the load after PAO would encourage regeneration of the degenerative cartilage and cartilaginous metaplasia within the acetabular fossa¹⁵. We found a significant difference in post-HHS (particularly the pain score) and the DAF between the two groups, suggesting that cartilage regeneration may be associated with the shape of the acetabular fossa (particularly the depth) rather than the degree of developmental dysplasia of the hip. There was no significant difference between the groups in terms of age, BMI, period between primary operation and second-look arthroscopy, and other radiographic parameters. In the fibrous cartilage formation group, redistribution of the load was thought to be carried out in the region that includes the acetabular fossa. There is an individual difference in the shape of the acetabulum. Pun et al. clearly indicated that dysplastic hips are globally deficient in

1 both cartilage and fossa dimensions on MRI and CT scans ¹⁶⁾. We believe that patients
2 with hip dysplasia who also have a deep fossa may not see improvement in postoperative
3 pain as quickly as others who have a shallower fossa. We acknowledge that there could
4 be other factors contributing to our postoperative results after PAO. However, this result
5 indicates that fibrous cartilage formation is a contributing factor to better postoperative
6 results.

7 If indeed the degree of postoperative pain from PAO is influenced by fibrous
8 cartilage of the acetabular fossa, surgeons may need to induce microfracturing in the
9 lateral margin of the acetabular fossa in patients to promote fibrous cartilage formation
10 ¹⁰⁾.

11 The present study has several limitations. First, this study had a small sample
12 size, with few participants in each group. However, this number of patients was sufficient
13 to conduct a preliminary investigation, such as the present study and other former works
14 ^{9,12)}. Second, we performed pathological examinations only in some of the patients who
15 were allocated to the formation group. This is due to the possibility that sampling of the
16 fibrous cartilage may adversely affect the patients, and thus, we could not perform
17 pathological examination in all patients. Third, we measured the DAF but were unable to
18 measure the dimension of the acetabular fossa. Measuring this dimension would provide
19 a better assessment of the outcome.

20 In conclusion, after performing second-look arthroscopy following PAO,
21 patients with postoperative fibrous cartilage formation in the acetabular fossa had a better
22 clinical outcome than those without this formation.

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Figure Legends

Figure 1. Computed tomography (CT) scans of the left hip showing the depth of the acetabular fossa (DAF).

- a. The CT slice matching with the step of the acetabular roof in the coronal plane.
- b. The enlarged image in the axial plane. DAF (red arrow) was measured using perpendicular lines from the line linking the front and back of the acetabular fossa (yellow line) to the deepest part of the acetabular fossa.

Figure 2. Hematoxylin and eosin-stained image of tissue obtained from the acetabular fossa during second-look arthroscopy. The pathohistological diagnosis was fibrous cartilage. The normal portion of the tissue was hyaline cartilage, demarcated by a border (yellow dotted line).

Figure 3. An example of a patient with fibrous cartilage formation after PAO (formation group). The acetabular fossa is within the dotted line.

- a. Arthroscopic view of the acetabular fossa before PAO.
- b. The acetabular fossa at the time of second-look arthroscopy. The yellow arrow indicates the fibrocartilage.

Figure 4. An example of a patient without fibrous cartilage after PAO (non-formation group). The acetabular fossa is within the dotted line.

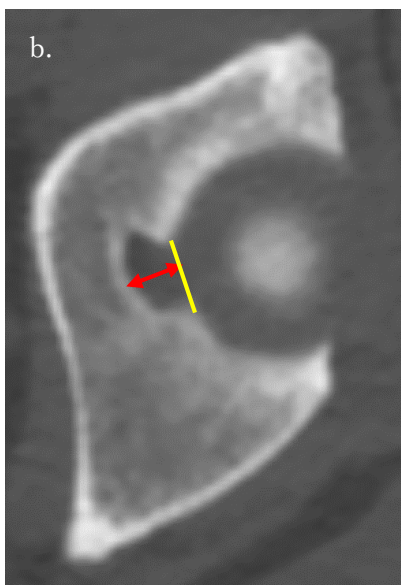
- a. Arthroscopic view of the acetabular fossa before PAO.
- b. The acetabular fossa at the time of second-look arthroscopy (17 months after primary surgery).

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2 Fig1.



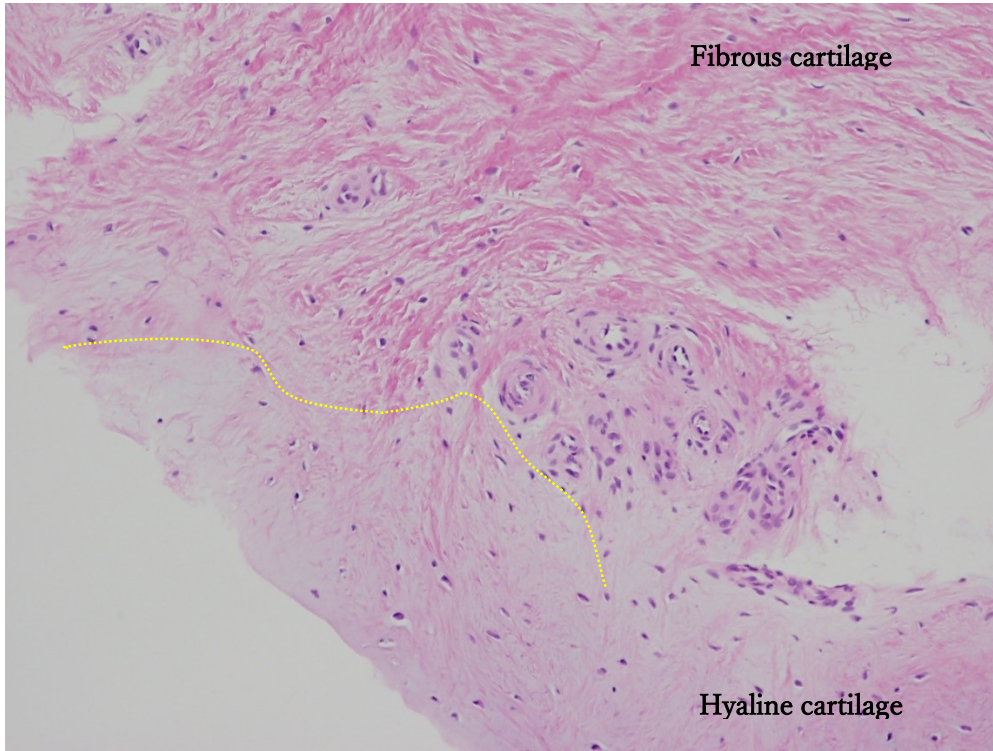
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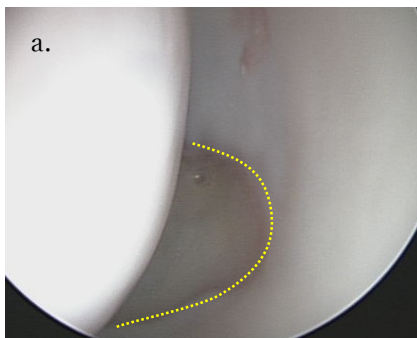
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6 Fig2.



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Fig3.



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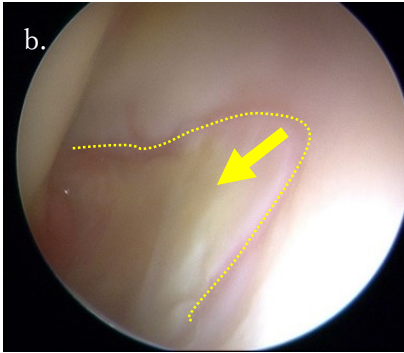


Fig4.

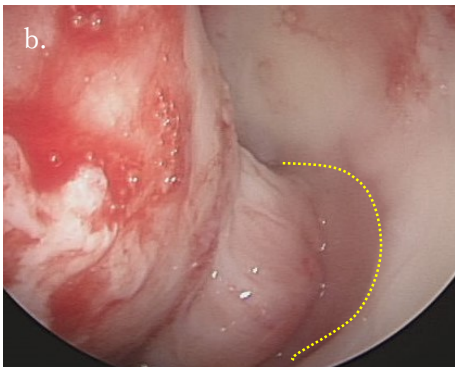
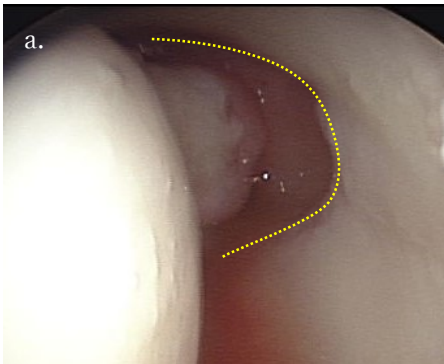


Table 1. Demographic Features, Pain, and Radiographic Parameters for the Formation and the Non-formation Groups

	Formation group (<i>n</i> = 37)		Non-formation group (<i>n</i> = 27)	
Age (years)	39.1 ± 12.0		36.6 ± 12.0	
Body mass index (kg/m ²)	22.3 ± 3.4		21.1 ± 3.6	
Period between primary surgery and second-look arthroscopy (days)	444 ± 94		465 ± 134	
DAF	6.67 ± 1.41		8.61 ± 1.46*	
Change in lateral CE angle	18.4 ± 6.7		17.0 ± 7.4	
Change in ARO	17.2 ± 5.6		15.5 ± 6.1	
Change in VCA angle	17.4 ± 8.0		14.5 ± 9.6	
	Preoperative	Postoperative	Preoperative	Postoperative
HHS	75.3 ± 11.2	94.6 ± 6.3	73.2 ± 12.4	88.6 ± 8.5*
Pain score in HHS	25.5 ± 7.3	40.4 ± 3.7	24.8 ± 8.5	37.1 ± 5.1*
Function score in HHS	48.4±11.3	54.1±5.2	48.4±10.6	51.7±7.2
lateral CE angle	10.1 ± 7.6	28.6 ± 6.4	11.1 ± 7.3	28.1 ± 5.7
ARO	20.7 ± 7.6	3.4 ± 5.5	18.9 ± 6.9	3.4 ± 3.5
VCA angle	22.9 ± 14.3	40.3 ± 12.3	27.0 ± 13.7	41.3 ± 9.2

Formation group: PAO patients with fibrous cartilage formation at second-look arthroscopy, non-formation group: PAO patients with no fibrous cartilage formation at second-look arth
HHS: Harris hip score, CE: center-edge, ARO: acetabular roof obliquity, VCA: vertical-center-anterior, DAF: depth of acetabular fossa.

*indicates a significant difference between the two groups.

roscopy.